

Photobiomodulation: Myths and facts

On the pathway to becoming mainstream

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While lasers and LEDs are widely used, the term “photobiomodulation” is rarely recognized outside of laser-based healthcare professions. Although it is frequently employed by veterinarians, chiropractors, and physiotherapists, many dentists still view it as science fiction. Even among experienced practitioners and researchers, misconceptions and misuse of terminology persist. This brief article aims to promote the use of accurate terminology within our profession, fostering greater understanding and broader adoption of this important and effective therapy.

Light therapy is a recent discovery – FALSE

- ◆ Niels Ryberg Finsen was awarded a Nobel Prize in 1903 for his phototherapy work using sunlight¹. He treated lupus vulgaris with intense focused sunlight
- ◆ Blue light is used to treat neonatal jaundice in the NICU to help break down the buildup of bilirubin pigment in the blood^{2,3}. UVB is essential for production of Vitamin D3 and is an effective treatment to stop or slow the progression of active vitiligo and helpful with improving psoriasis⁴ (Fig. 1). Red and blue light combined can be effective for inflammatory acne and broad-spectrum light can help reset circadian rhythms and reduce depressive symptoms⁵
- ◆ Endre Mester's work showing healing with lasers in 1967 kickstarted modern research^{6,7}. The hair on shaved mice



Fig. 1 UV phototherapy for psoriasis

grew more quickly when exposed to the laser energy

- ◆ There are different forms of light treatments that can vary in dose, manner of use (eg. combined with exogenous chromophores), desired biological and clinical therapeutic outcome

Photobiomodulation is just a heat treatment – FALSE

- ◆ PBM is a non-surgical, non-ablative, non-thermal process causing photo-physical and photochemical events at various biological scales⁸
- ◆ It is a form of light therapy that has been known by many terms including low-level laser (or light) therapy (LLLT), low-intensity laser therapy, low-power laser therapy, cold laser, soft laser, photostimulation and photobiotherapy
- ◆ Photobiomodulation (PBM) is the accepted terminology and became a medical subject heading by the National Library of Medicine in 2016 which distinguishes it from therapies relying on thermal effects⁸
- ◆ Lower power is used for stimulation, healing and reduction of inflammation while higher power and higher frequencies are used for neural blockade⁹⁻¹¹
- ◆ PBM is used to accelerate wound healing and tissue regeneration, increase circulation, reduce acute inflammation, reduce acute and chronic pain and help restore normal cellular function
- ◆ Wavelengths between ~600 to 1100 nm are less strongly absorbed by melanin, hemoglobin and water allowing penetration without heat generation¹²

Photobiomodulation is a pseudoscience – FALSE

- ◆ Nearly 800 human Randomized Control Trials, and some 7000 basic and clinical, animal and human studies have been done. Around 100 articles per month are being published on PBM

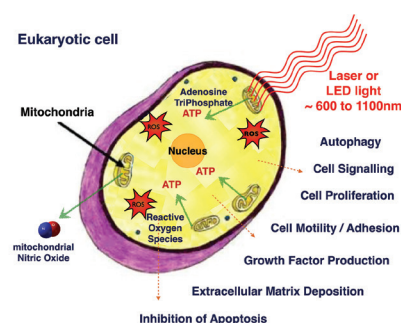


Fig. 2 Mechanism of action of photobiomodulation

- ◆ The main mechanism by which PBM works is light absorption in the mitochondria within cells. This photochemical reaction increases ATP production, transiently increases reactive oxygen species (ROS) and releases mitochondrial nitric oxide. This causes a cascade of growth factors, increasing cell signalling, gene transcription and cell metabolism^{13,14} (Fig. 2)
- ◆ Other PBM mechanisms include modulation of membrane receptors/transporters and ion channels (opsins, AHR, TRPV1) and induction of extracellular growth factors such as TGF- β ¹⁵
- ◆ At the tissue level this leads to vasodilation, improved lymphatic drainage, reduced pain, less trismus, improved range of motion and less nerve and cellular tissue death^{16,17}
- ◆ PBM is used to treat dental and non-dental conditions across the whole body^{18,19}. Many painful and previously poorly managed conditions such as ulcers, burning mouth syndrome, oral mucositis, and post-herpetic neuralgia can experience immediate pain relief²⁰⁻²⁵
- ◆ Dental conditions treated with PBM include dental sensitivity²⁶, accelerating wound healing and reducing graft pain¹⁶, minimising pain and swelling post-extraction²⁷, improving orthodontic tooth movement²⁸, overcoming nerve



Fig. 3. Ramsay Hunt Syndrome – facial palsy – Before treatment (A), 5 months after PBM therapy (B)



Fig. 4. Photobiomodulation treatment for oral mucositis with 650 nm Ploon laser

injury²⁹, enhancing bone formation and implant stability^{30,31}, reducing severity of oral mucositis and aphthous ulcers^{23,32}, preventing acute flare-ups of cold sores (herpes simplex infections)³³, trigeminal neuralgia³⁴, facial palsy^{24,35} (Fig. 3), managing TMJ disorders³⁶ and deactivating myofascial trigger points amongst many more³⁷

- ◆ Oral mucositis, a common complication of chemotherapy, radiotherapy, or hematopoietic stem cell transplants that results in large and painful mouth ulcers, is recommended for treatment with specific PBM protocols worldwide, following ESMO, NICE, and MASCC/ISOO guidelines^{38–40} (Fig. 4)
- ◆ World Association for photobiomodulation Therapy (WALT) guidelines recommend PBM for a range of cancer care complications, including xerostomia, radiodermatitis, dysphagia, dysgeusia, lymphedema, peripheral



Fig. 5. NovoTHOR full-body LED lightbed

neuropathy, fibrosis and other conditions⁴¹

- ◆ PBM has been used to treat pulmonary disease such as pneumonia, asthma and COPD^{42,43}, the loss of taste and smell associated with COVID^{44,45}, reducing brain fog and other long COVID complications⁴⁶, Parkinson's disease⁴⁷, fibromyalgia⁴⁸, athlete recovery from elite-level sport^{49–54}, skin, pressure and venous ulcers⁵⁵, diabetic wounds^{55,56}, dry age-related macular degeneration^{57,58}, post-herpetic neuralgia such as from shingles⁵⁹, pain intensity and post-surgery inflammation following total hip arthroplasty⁶⁰

PBM must be done by lasers because the light is coherent – FALSE

- ◆ A distinctive characteristic of lasers is their coherent light, meaning the light waves share the same frequency and are in phase. This property is utilised for photothermal ablation
- ◆ All non-ionizing light sources, including lasers, LEDs, and broadband light, in the visible and near-infrared spectrum, can be used for PBM⁸
- ◆ Red and near infra-red (NIR) LEDs for PBM can be found in the form of torches, bulbs, panels, flexible wraps and even full-body lightbeds (Fig. 5)
- ◆ The wavelength, light source, power, pulse frequency, beam area, irradiance, exposure time and application technique will all affect the reproducibility of treatment
- ◆ The terms 'low level' and 'high level' are inaccurate and should be avoided⁶¹

Stronger light leads to better results – TRUE & FALSE

- ◆ Light needs to be of sufficient strength to penetrate the target tissues. Deeper tissues will need stronger light or longer treatments to receive the fluence required to have an effect²⁹
- ◆ Penetration depths will vary by wavelength. Lasers and LEDs can penetrate up to 5cm into tissues with sufficient beam power and irradiance^{18,62}
- ◆ Due to the 'Biphasic Response', there is a 'Goldilocks' zone with an optimal biological response. Too little or too much light results in minimal or inhibition of healing respectively^{63–65} (Fig. 6)
- ◆ All dental diode lasers covering the red to NIR spectrum are suitable for PBM

Larger spot size (diameter of the focused laser beam) is better – TRUE

- ◆ Small fibre lasers have a divergent output and a gaussian beam profile

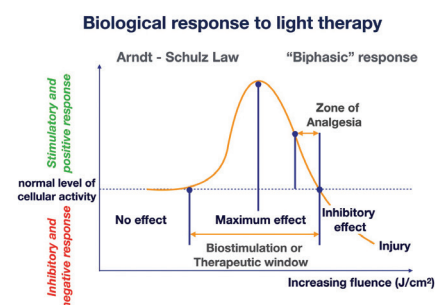


Fig. 6. The Arndt-Schulz curve showing the "Biphasic" biological response curve of cells to light therapy

rendering only the inner 1/3 usable for PBM. Moreover, the beam must continually be moving to create a uniform fluence over a large area. Many manufacturers now make handpieces for PBM treatment to improve their reproducibility⁶⁶

- ◆ Photobiomodulation handpieces now exist that have a homogenous (flat-top), collimated beam profile (Fig. 7) such as the Genova and MarCo handpieces that attach to the Nd:YAG 1064 nm laser output of the Fotona LightWalker (Fig. 8).
- ◆ Large LED handpieces and large homogenous profile laser beams mean that affected areas can be treated more quickly but also more uniformly due to less relative scattering of the light^{67,68}
- ◆ Improved reporting of the parameters used for PBM will enable better comparisons of wavelength, energy and energy density as well as application technique amongst other parameters⁶⁹
- ◆ These flat-top beam profiles have been shown to improve PBM outcomes by anywhere from 1.5 to 2 times in both cellular and clinical trials in animal and humans compared with gaussian beam profiles^{67,70,71}.
- ◆ PBM has been found to be equal to pharmacotherapy for the treatment of oral neuropathic pain conditions such as burning mouth syndrome and trigeminal neuralgia^{20,34,72}

Only the tissues are exposed to the light will be modulated – FALSE

- ◆ Cell-free mitochondria have been found to circulate in the blood which means that mitochondria upregulated by PBM can travel to distant organs like the brain and internal organs and improve their function and reduce inflammation⁷³
- ◆ Using ultra-sensitive light equipment it has been found that small amounts of UV, red and NIR light known as biophotons are released from nerve tissue. Biophoton emission can also be induced in stressed/

MOBILE MEDICAL SYSTEMS

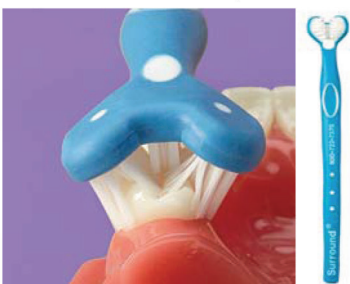
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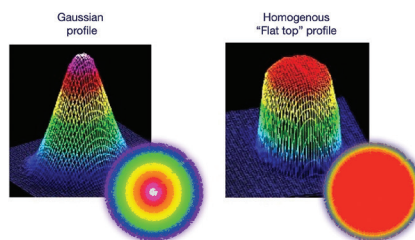


Fig. 7 Gaussian vs Flat-top beam profiles

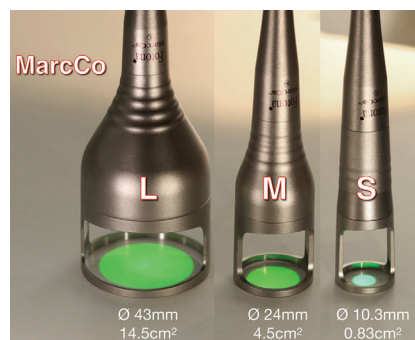


Fig. 8 MarcCo handpieces – Flat-top, collimated
beam profile to fit Fotona LightWalker

inflamed cells through the use of PBM. These upregulated neurons will then stimulate nearby neurons by biophotons travelling through axons in direct contact or by transmission through the extracellular matrix^{74,75}

- ◆ PBM can reduce proinflammatory cytokines like TNF- α , IL-1 β , IL-6 and a range of other interleukins while increasing anti-inflammatory cytokines like IL-4 and IL-10. These seem to reduce oedema, neutrophil influx and other inflammatory markers throughout the body^{76,77}
- ◆ Laser therapy has been shown to increase the proliferation, migration, and differentiation of mesenchymal stem cells.^{78,79} These stem cells have been helpful in tissue regeneration at sites distant to the light exposure such as heart^{80,81}, kidney and bone marrow⁸²
- ◆ 60s of exposure time to Nd:YAG 1064 nm at PBM levels has shown to have a bactericidal effect on biofilms of *Streptococcus mutans*⁸³ and *Actinomyces israelii*⁸⁴, as well as reduce fungal growth after 24 hours⁸³

Hospitals and insurance companies are supporting photobiomodulation – TRUE

- ◆ PBM devices have been cleared for marketing by the Therapeutic Goods Association as adjunctive devices for the healing, inflammation and the temporary relief of pain⁸⁵.
- ◆ Sydney Adventist Hospital, St George Hospital Dermatology Department, Mater Hospital Brisbane, The Royal Children's Hospital Melbourne all

use PBM on their patients. Peter MacCallum Cancer Centre in Melbourne has trialled the use of PBM for the management of the side effects of cancer treatment. Chris O'Brien Lifehouse has PBM units in their lymphoedema department. Sydney Children's Hospital and other hospitals are considering PBM equipment

- ◆ The Australian Medical Photobiomodulation Association (ampa.net.au) aims to promote the advancement of science, research and practice of photobiomodulation in mainstream medicine and allied health. The current president of AMPA is Dr Joseph Ryan, an Oral Medicine specialist and senior lecturer in Oral Pathology at Charles Sturt University
- ◆ The 30th WALT Congress was recently held in August 2024 in London. Topics for the event included neurorhabilitation; reproductive health; dentistry and oral care; bone and musculoskeletal; metabolic and autoimmune disorders; stem cells and regenerative medicine; wound care; pain management and addiction; dermatology; aesthetic medicine; sports and rehabilitation; and ophthalmology (waltbpm.org)
- ◆ US Congress passed the Opioid Crisis Response Act in 2018, and since then, there have been several studies on the use of PBM for opioid use disorder⁸⁶⁻⁸⁸. They now support PBM as a method for alleviating pain, reducing the need for opioids and stimulating healing
- ◆ Australia has a dental reimbursement code (945) for photobiomodulation. The American Dental Association is currently ratifying its Technical Report No. 189 on PBM while the FDA is updating its PBM product codes to extend its use

Red light therapy as it is more commonly known to the public has been promoted by celebrities and influencers. LED facemasks and light panels are used to reduce premature aging⁸⁹, stretch marks⁹⁰, hyperpigmentation⁴ and acne^{4,91}. However, the quality of the masks varies, with some providing minimal benefits.

There is an increasing volume of published research, clearer definitions of therapy efficacy, and a growing range of conditions shown to benefit from PBM. With its safety well-established, along with increased support from government bodies and insurance companies, there is hope that PBM will gain recognition within mainstream medicine and be accepted as a non-invasive, non-surgical, and effective treatment for a variety of conditions. ◆

For a complete list of references email
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